Continuous Fog Chamber

Order No. 1009040

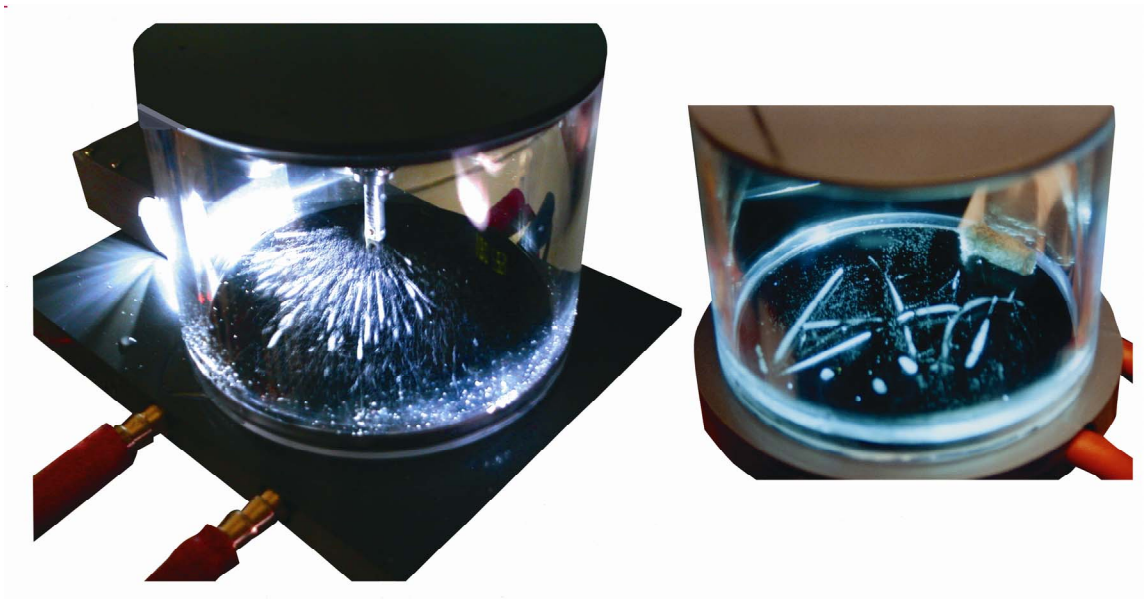

Fig: α ray emitted from an Ra 226 specimen

Fig: α ray emitted from an incandescent mantel or environmental radiation

Physical principle

α , β and γ rays (e.g. as emitted by 226 Ra) can, as a result of their ionising effect, be detected in a fog chamber. The particles possess considerable energy (several MeV) after the decay of 226 Ra, and this enables it to ionise gas molecules through collision. If a super saturated environment of isopropanol or ethanol is provided, the ions created through particle bombardment form condensation particles that, in turn, contribute to the formation of fog. A fog track forms along the trail of the radioactive particles, similar to the condensation trails that form behind by a jet flying in the stratosphere. Steam super saturation can be achieved by engineering a temperature drop from high to low in a receptacle filled with alcohol steam.

The upper receptacle area is generally at room temperature (super saturation does not yet occur here). The lower receptacle zone is cooled dramatically, causing super saturation within the temperature fall range in which a radioactive particle can be detected by its fog track. Further expansion is unnecessary, as the procedure occurs continuously, provided adequate alcohol is available. Bright lateral illumination can make this procedure visible to a larger group of persons.

General description

Receptacle
High-performance LED illumination
Base plate with Peltier element and water cooling
Lid with reservoir for isopropanol (75%-90%)

Fig. 1 Fog chamber components

Scope of delivery

- ✓ Base plate with Peltier element and heat exchanger
- ✓ High-performance LED illumination (plug-in unit) with integrated blower
- ✓ Plexiglas receptacle
- ✓ Lid with reservoir for isopropanol
- ✓ Support stand 12mm x 120mm (not illustrated)

The CL09040 fog chamber is a compact construction on an aluminium base plate. The plate is 125 x 125 mm^2 with lateral plug-in LED illumination. It contains a heat exchanger operated with tap water (approx. 2 litres/min) that cools the warm side of a Peltier element. The required operating temperature of – 32 °C on a carbonised aluminium cooling plate is generated on the cold side of the Peltier element. The lowest temperature

reached by this plate depends on the water temperature. The water temperature should be below 20°C if ionisation tracks are to become visible (optimum results are achieved at water temperatures between 14°C and 18°C). Surface temperatures of up to -34°C are achieved here on the cold side of the Peltier element.
The water temperature can be checked with a submersible thermometer inserted laterally into the heat exchanger. Tracks of radioactive particles are observed within the Plexiglas receptacle. Its internal diameter and height (both 100 mm) facilitate a comfortable lateral view of the black cooling plate, against which the ionisation tracks appear in contrast.

Note

The fog chamber should be mounted on a stable pedestal, using the stand holder supplied. The pedestal is not included in the scope of delivery. Ensure that hoses for water cooling and power supply cables are laid so that pupils do not catch themselves when passing the test structure.

Illumination and cooling

The special high-performance LED illumination is plugged in from the side and also supplied with power via the power supply unit supplying the cooling element. The Plexiglas receptacle fits exactly on the aluminium plate and rests on the base plate. It has a ∅ 5 mm hole in the lower lateral area that should be aligned with the ∅ 4 mm hole in the side of the aluminium cooling plate. A temperature sensor (not included in the scope of delivery) can be inserted through both holes, should it prove necessary to determine the temperature of the cooling plate.

Filling with isopropanol

The underside of the receptacle lid contains a felt pad that is soaked with **5** ml isopropanol or ethanol (Fig. 2). Do not use pure isopropanol, but rather ***75% to 90%*** alcohol. ***The percentage of water influences the effectiveness of condensation***. Too much water causes the base plate and/or specimen to freeze rapidly. Pure alcohol prevents reliable operation.

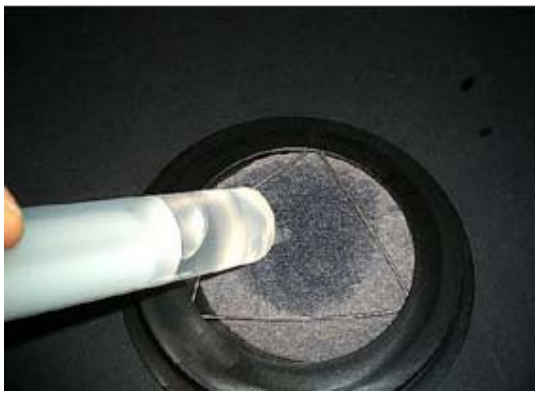

Fig. 2
Application of isopropanol or ethanol to the felt in the receptacle lid

Note

Please ensure that no naked light or ignition sparks are in the immediate vicinity when handling isopropanol or ethanol. Bunsen burners or hot plates should not be operated in the vicinity, and smoking should also be forbidden.
Please note that alcohol fumes caused by residual isopropanol or ethanol on the felt pad in the lid can be present after the trial is completed. Ensure that the room is well ventilated during and after the experiment.

A suitable 226 Ra specimen (CL09018 radiation rod) can be screwed into the base plate from below with its radiation aperture aligned with the centre of the chamber on the upper surface of the plate (Fig. 3).

Fig. 3 Insertion of radiation rod in the fog chamber

After fitting the lid and applying 12..15V operating voltage, tracks of radioactive particles from the specimen can be observed in the receptacle after approximately 5 minutes if the cold water flow is adequate and a cooling plate temperature of below –30 °C is achieved. The procedure can be observed for as long as the felt pad in the lid contains alcohol. The extreme temperature drop from high to low causes the aluminium plate to act as a cryogenic pump, and the felt pad dries out. Repeated soaking with alcohol continues the procedure.

Commissioning of continuous fog chamber

The following equipment is required and the following preparations should be made:

1. ***Controlled power supply unit 0...15 V, 0...10 A***. A simple variable transformer with power rectification is inadequate. The fog chamber can also be operated with a 12 Volt car battery.

2. ***Cold water connection*** with approx. 2 litres / minute flow. The water temperature should not exceed 20 °C. Water pipes are usually very long in schools, and lukewarm water generally emerges initially after a tap is turned on. However, the water will cool to the required temperature if it is allowed to run for some time.

3. Prepare the classroom so it can be darkened if necessary.

4. ***Stand pedestal*** with a central hole of at least ∅ 12 mm.

5. ***Radioactive specimen***. The CL 09018 radiation rod consisting of 226 radium is the easiest to handle, with a completely harmless emission of 3.7 kBq. The fog chamber is equipped with a screw fitting for receiving this radiation rod. Any other preferred radioactive specimen can be deposited on the chamber floor (e.g. incandescent thorium mantle, or naturally radiating specimens such as radioactive rock, etc.). Ionisation tracks of natural environmental radioactivity can be made visible without a radioactive specimen (approx. 20-30 instances of decay every minute).

Screw the metal rod with the M6 x 10 thread into the threaded hole provided for this purpose on the underside of the fog chamber. Position the chamber on a stable tripod. The following components are located on the side edges of the base plate:

1st side Red signal LED and hole for measuring the water temperature
This side should be turned towards the observer (Fig. 4)

Fig. 4 Signal LED (overheating protection) and hole for temperature measurement

Note

The power supply should be interrupted if the LED illuminates. The thermostatic switch activates again when the warm side of the Peltier element has cooled to approx. 36°C.

2nd side The sockets for the operating voltage of 12...15 Volts are located to the right of the 1st side. Polarity is + red, - black. The chamber has polarity reversal protection to prevent anything happening in the event of incorrect polarity (Fig. 5). The power supply unit is connected here.

Fig. 5 Connections for supply voltage (12-15V / 8A)

Note

The plate in the receptacle can reach a temperature of up to minus 36°C cold during operation of the fog chamber. Touching it can lead to freeze sticking. One should therefore wait approx. 5 minutes after disconnecting the operating voltage before cleaning the plate. The plate can be heated quickly to room temperature with a hairdryer if necessary.

3rd side 2 sunken sockets are located opposite the first side at the rear into which the LED lamp housing can be plugged. Plug in the lamp housing so that the light shines on the black aluminium plate. Polarity reversal protection is also provided here (Fig. 6)

Fig. 6 Connections for plug-in LED illumination

Note

Never confuse the LED illumination sockets with those for the power supply.
This would lead to destruction of the fixed voltage controller in the fog chamber !

4th side

A water connection for ∅10 mm non-pressure rubber or plastic hoses found everywhere in schools (in chemistry labs) is located at the front left (Fig. 7). One side is connected to the water supply, the other acts as the water drain. Cold water only forms a water channel with a maximum of 2 litres/min. The water temperature is decisive, not the volume.

Fig. 7 Connection for cooling water circuit

Plug the lamp housing into the socket intended for this purpose (Fig. 6)

Connect the cooling water and turn it on. Allow the water to run for a longer period of time if necessary until it is cold enough.

Insert a radioactive specimen into the chamber interior by unscrewing the little knurled protective cap. The CL 09018 radiation rod can be screwed into the aluminium cooling plate from the underside of the base plate, directing its emission towards the centre of the plate. Other specimens (e.g. incandescent mantels, radioactive rock, old clock faces) are simply placed on the edge of the aluminium cooling plate.

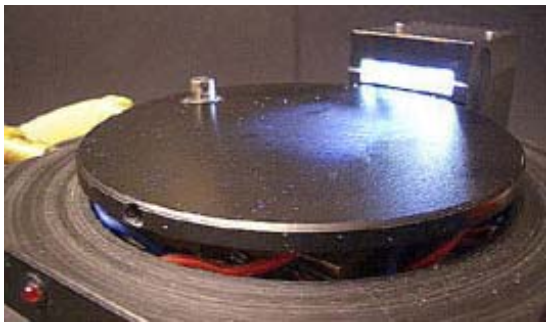

Fig. 8 Fog chamber prepared with radioactive specimen

Position the receptacle on the base plate so that the lateral hole in the receptacle is aligned with the lateral hole in the aluminium plate. Both holes are on side 1 of the base plate (i.e. facing towards the observer).

Insert a temperature measuring instrument through both holes if necessary.

Soak the felt pad in the lid with approx. 5 ccm ethanol or, preferably, isopropanol (Fig. 2) and mount it on top so that the felt pad is inside the chamber. The felt pad should contain just enough alcohol so that no drops are visible.

The fog chamber is now ready for operation. Switch on the power supply unit and adjust the power supply slowly to the setpoint value of 15 Volts. Approximately 8 Amps flow. The LED lamp functions from approximately 7 Volts onwards and projects a beam of white light over the aluminium cooling plate. The observer looks into this light.

Observation of ionisation tracks in the continuous fog chamber

A thermometer inserted in the aluminium cooling plate now indicates a rapid fall in plate temperature. A diffuse fog forms over the floor of the chamber from – 10 °C onwards, indicating that the felt pad in the lid is soaked with alcohol that is now condensing over the plate.
A further temperature drop to – 34 °C leads to atmospheric super saturation after 5 ... 10 minutes, and ***the first fog tracks become visible***. They emanate from the specimen, indicating the presence of radiation.

The chamber is soon filled with fog tracks.

A ring-shaped moisture precipitate appears on the receptacle exterior. This is harmless and dispersed to a great extent by the blower integrated in the LED lamp.

Fog tracks can be seen as long as the felt pad in the lid contains enough alcohol. This lasts for approx. 1 hour where 5ml of isopropanol is involved.

Tricks

Fog tracks can become ill defined and blurred as a result of excessive ions in the chamber. Lightly rubbing the Plexiglas receptacle with a soft cloth or fleece helps here, as the frictional electricity generated removes excess ions. Moisture condensation and icing in the lower area of the receptacle can be removed with a warm air flow, thus re-establishing the former visual contrast.

Warning

Substances that reduce the surface tension of liquids can seriously disturb the formation of fog tracks.

Any contact between the chamber and soapy solutions should therefore be avoided, particularly during cleaning work.

Decommissioning the continuous fog chamber

- The power supply unit and its output voltage is first reduced and subsequently deactivated. The measuring leads are removed.
- The cooling water supply is then turned off.
- Remove the temperature sensor (if present)
- Remove the receptacle lid and deposit for drying.
- Remove the receptacle and dry with a soft absorbent cloth. (**Note**: there should be no residual alcohol on the receptacle, as it can otherwise develop micro-cracks and become dulled.).
- Remove the LED illumination.
- Remove the radioactive specimen, store safely and screw in the cover cap from below if necessary.
- Dry the aluminium plate (**Tip**: the plate can be heated to room temperature quickly with a hairdryer!)

Note

Please do not use a cloth soaked in water, as the plate can be up to -34°C cold, and the cloth can freeze stick to it immediately. However, in the event of this happening, warm the plate up (e.g. with a hairdryer) and then remove any residual paper.

Do not use detergents or other agents that wet surfaces

- Remove the water hoses and blow out the water cooler.

Technical data

Power supply:	stabilised power supply unit 12 ... 16 Volts DC, 6 ... 8 Amperes
Water cooling:	approx. 2 litres/min
Illumination	high-performance plug-in LED gap lighting (room light dimmed)
Steam formation:	a felt pad in lid soaked with 5 ml isopropanol or ethanol
Temperature measuring:	Water : Plug-in sensor in lateral heat exchanger opening Cool plate : Plug-in sensor in lateral heat receptacle and cooling plate opening
Operating temperature:	Water : 14 °C ...- 20 °C Cooler : -29 °C ... –34 °C
Operating duration:	Approx. 5-10 minutes waiting period after preparation and activation. The procedure can be viewed for approx. 1 hour before it is necessary to refill the alcohol
Fusing:	The chamber is protected against polarity reversal and automatically deactivated at 65 °C heat exchanger temperature when operated without cooling water, reactivating at 35 °C again (bimetallic switch).
Care:	The base plate and cooler should be wiped with an absorbent cloth. Polish the receptacle with Plexiglas polish after use if necessary.
Important:	**The fog chamber interior (plate and receptacle) should be kept free of grease and soap and cleaned with a degreasing agent if necessary. Do *not* use detergent.**
Caution:	**The receptacle should not be exposed to alcohol for a longer period of time after use, as micro-cracks will otherwise develop in the Plexiglas.**

In the event of malfunction

	Error / Symptom	***Possible cause and remedy***
1.	Nothing happens after the chamber is activated, despite waiting for a long period.	Incorrect power supply unit, or incorrectly connected. Does the power supply unit provide 16 Volts at min. 8 Amps? Polarity reversal protection is provided. Check polarity: red is + black is – A current should flow on the power supply unit when the voltage is slowing increased. *Further error diagnosis:* Connect a DC ammeter to the main current circuit. A current of several Ampere should flow when the voltage is increased.
2.	LED illumination is not working	Examine as in Item 1 Is the lamp housing plugged correctly into the respective socket at the rear of the base plate? Light emission occurs above via the aluminium cooling plates. *Further error diagnosis:* Turn the base plate around so that the rear is at the front. The sunken sockets face you, and + is to the right. Measure the lamp voltage with a DC voltmeter. It should be 5 Volts (Fig. 6). *Further error diagnosis:* Connect 5 Volts to the disconnected lamp housing: + is to the left, and the light should be shining at you now.
3.	The signal LED triggers after some time, and current ceases to flow (Fig. 4)	No or too little cooling water. A temperature safety switch is integrated in the base plate that triggers at 65 °C. Either wait one hour until the temperature has dropped below 35 °C again, or assist the process by introducing a flow of cold water. Measure the water temperature (at front). It should be less than 20 °C.

4.	No fog tracks are formed	Several possible causes: a) No radioactive specimen. Ensure that a radioactive specimen is present in the chamber. Check with a Geiger counter if necessary whether the specimen really emits radiation. b) Temperature is not low enough. The temperature of the aluminium plate should be –32 °C. This is achieved with a water temperature of less than 20 °C and a Peltier current of approx. 8 Amps. Further tests as in Item 1. c) Too little or no isopropanol. Check the felt pad in the lid. It should be damp to well soaked with alcohol. Purified ethanol can also be used instead of isopropanol. An indication of commencing operation is diffusive fog formation prior to fog tracks forming. d) Soap residue effectively prevents the formation of a supersaturated zone. Switch off the fog chamber and allow it to warm up. Clean the receptacle and lid without the felt pad using lukewarm water. Dry and wash out the felt pad (do not use soap!), subsequently drying it again. The anodised aluminium plate is particularly adept at gathering stubborn dirt. Plug the gap between the aluminium plate and base plate, rinse the aluminium several times with lukewarm water, then dry it and subsequently clean with alcohol.